DWSAP Form for PBE (Groundwater)

Physical Barrier Effectiveness (PBE) – Ground Water, page 1 of 2

Source Name:_____ Source No.:_____

PARAMETER	POINTS Unconfined		Confined	
A. TYPE OF AQUIFER				
Confinement *(up to **50** points maximum)* choose one				
a. Unconfined, Semi-confined, Fractured Rock, Unknown	0			
b. Confined			50	
B. AQUIFER MATERIAL (Unconfined Aquifer)				
Type of materials within the aquifer *(up to **20** points maximum)* choose one				
1. Porous Media (Interbedded sands, silts, clays, gravels) with continuous clay layer minimum 25' thick above water table within Zone A	20			
2. Porous Media (Interbedded sands, silts, clays, and gravels)	10			
3. Fractured rock *	0			
(* Low Physical Barrier Effectiveness - no further questions required)				
C. PATHWAYS OF CONTAMINATION (All Aquifers)				
Presence of Abandoned or Improperly Destroyed Wells *(up to **10** points maximum)*				
1. Are they present within Zone A (2-year time of travel (TOT) distance)?				
a. Yes or unknown	0		0	
b. No	5		5	
2. Are they present within Zone B5 (2- to 5-year TOT distance)?				
a. Yes or unknown	0		0	
b. No	3		3	
3. Are they present within Zone B10 (5- to 10-year TOT distance)?				
a. Yes or unknown	0		0	
b. No	2		2	
D. STATIC WATER CONDITIONS (Unconfined Aquifer)				
Depth to static Water (DTW) = _____ feet *(up to **10** points maximum)* choose one				
1. 0 to 20 feet	0			
2. 20 to 50 feet	2			
3. 50 to 100 feet	6			
4. > 100 feet	10			
E. WELL OPERATION (Unconfined Aquifer)				
Depth to Uppermost Perforations (DUP) DUP = _____ feet				
Maximum Pumping Rate of Well (Q) Q = _____ gallons/minute				
Length of screened interval (H) H = _____ feet				
[(DUP – DTW) / (Q/H)] = *(up to **10** points maximum)* choose one				
1. < 5	0			
2. 5 to 10	5			
3. > 10	10			

Physical Barrier Effectiveness – Ground Water, page 2 of 2

Source Name:_____ Source No._____

PARAMETER	POINTS Unconfined		Confined	
F. HYDRAULIC HEAD (Confined Aquifer)				
What is the relationship in hydraulic head between the confined aquifer and the overlying unconfined aquifer? (i.e. does the well flow under artesian conditions?) *(up to **20** points maximum)* choose one				
1. head in confined aquifer is higher than head in unconfined aquifer under all conditions			20	
2. head in confined aquifer is higher than head in unconfined aquifer under static conditions			10	
3. head in confined aquifer is lower than or same as head in unconfined aquifer			0	
4. unknown			0	
G. WELL CONSTRUCTION (All Aquifers)				
1. Sanitary Seal (Annular Seal) Depth = _____ feet *(up to **10** points maximum)* choose one				
a. None or less than 20 feet deep	0		0	
b. 20 to 50 ft deep	6		10	
c. 50 ft or greater	10		10	
2. Surface seal (concrete cap) *(up to **4** points maximum)* choose one				
a. Not present or improperly constructed	0		0	
b. Watertight, slopes away from well, at least 2' laterally in all directions	4		4	
3. Flooding potential at well site *(up to **1** point maximum)* choose one				
a. Subject to localized flooding (i.e. in low area or unsealed pit or vault) or Within 100 year flood plain	0		0	
b. Not subject to flooding	1		1	
4. Security at well site *(up to **5** points maximum)* choose one				
a. Not secure	0		0	
b. Secure (i.e. housing, fencing, etc.)	5		5	
Maximum Points Possible	70		100	
POINT TOTAL FOR THIS SOURCE				

Physical Barrier Effectiveness SCORE INTERPRETATION

Point Total		Effectiveness	
_____0 to 35	=	**Low**	(includes all sources in Fractured Rock)
_____36 to 69	=	**Moderate**	
_____70 to 100	=	**High**	

DWSAP Scoring System

- PCA Risk Ranking Points:
  - very high 7
  - high 5
  - moderate 3
  - low 1
- Physical Barrier Effectiveness Points:
  - low 5
  - moderate 3
  - high 1
- Zone Points
  - Surface Water:
    - Zone A 5
    - Zone B 3
    - watershed 1 (or 5, if no zones defined)
  - Groundwater:
    - Zone A 5
    - Zone B5 3
    - Zone B10 1

To which PCAs is a Water Source vulnerable?

Vulnerability Matrix for SURFACE WATER SOURCES

The cutoff point for vulnerability is **11**. The drinking water source is considered Vulnerable to all PCA's with Vulnerability Score greater than or equal to **11** (shaded boxes).

PCA points	Zone points		PCA + Zone points	PBE Points			Vulnerability Score PCA + Zone + PBE points		
Risk Ranking	Zones Defined	Zones Not Defined		Low	Med	High	PBE Low	PBE Med	PBE High
VH (7)	A (5)		12	5	3	1	17	15	13
VH (7)	B5 (3)		10	5	3	1	15	13	11
VH (7)	B10 (1)		8	5	3	1	13	11	9
VH (7)	Unknown (0) *		7	5	3	1	12	10	8
H (5)	A (5)		10	5	3	1	15	13	11
H (5)	B5 (3)		8	5	3	1	13	11	9
H (5)	B10 (1)		6	5	3	1	11	9	7
H (5)	Unknown (0) *		5	5	3	1	10	8	6
M (3)	A (5)		8	5	3	1	13	11	9
M (3)	B5 (3)		6	5	3	1	11	9	7
M (3)	B10 (1)		4	5	3	1	9	7	5
M (3)	Unknown (0) *		3	5	3	1	8	6	4
L (1)	A (5)		6	5	3	1	11	9	7
L (1)	B5 (3)		4	5	3	1	9	7	5
L (1)	B10 (1)		2	5	3	1	7	5	1
L (1)	Unknown (0) *		1	5	3	1	6	4	2

, if the Vulnerability Score is 11 or

Vulnerability Matrix for GROUND WATER SOURCES

The cutoff point for vulnerability is **8**. The drinking water source is considered Vulnerable to all PCA's with Vulnerability Score greater than or equal to **8** (shaded boxes).

PCA points	Zone points	PCA + Zone points	PBE Points			Vulnerability Score PCA + Zone + PBE points		
Risk Ranking	A, B5, B10		Low	Med	High	PBE Low	PBE Med	PBE High
VH (7)	A (5)	12	5	3	1	17	15	13
VH (7)	B5 (3)	10	5	3	1	15	13	11
VH (7)	B10 (1)	8	5	3	1	13	11	9
VH (7)	Unknown (0) *	7	5	3	1	12	10	8
H (5)	A (5)	10	5	3	1	15	13	11
H (5)	B5 (3)	8	5	3	1	13	11	9
H (5)	B10 (1)	6	5	3	1	11	9	7
H (5)	Unknown (0) *	5	5	3	1	10	8	6
M (3)	A (5)	8	5	3	1	13	11	9
M (3)	B5 (3)	6	5	3	1	11	9	7
M (3)	B10 (1)	4	5	3	1	9	7	5
M (3)	Unknown (0) *	3	5	3	1	8	6	4
L (1)	A (5)	6	5	3	1	11	9	7
L (1)	B5 (3)	4	5	3	1	9	7	5
L (1)	B10 (1)	2	5	3	1	7	5	1
L (1)	Unknown (0) *	1	5	3	1	6	4	2

* Source is considered vulnerable to types of PCAs that are Unknown, if the Vulnerability Score is 8 or higher.

DWSAP Method

Principle Motivation of Ranking

- Most PCAs will rank as "moderate"
- The PCAs with the highest risk of polluting the water source will rank as "high" => should be the focus of protection activities
- Negligible PCAs will rank as "low"

DWSAP Method

Potential Pitfalls

- Comparison of Apples & Oranges: 20 pts Example
  - Unconsolidated sediments w/ clay layer (20 pts), water level depth 0-20 ft (0 pts), no sanitary seal (0 pts)
  - Unconsolidated sediments w/o clay layer (10 pts), water level depth greater than 100 ft (10 pts), no sanitary seal (0 pts)
  - Unconsolidated sediments w/o clay layer (10 pts), water level depth 0-20 ft (0 pts), sanitary seal 50 ft or thicker (10 pts)
  - Fractured rock aquifer (0 pts), water level depth greater than 100 ft (10 pts), sanitary seal 50 ft or thicker (10 pts)

Index & Overlay Method

Example: DRASTIC (Aller, 1987; EPA 1985)

- Depth to groundwater (5)
- Recharge (4)
- Aquifer media (3)
- Soil media (2)
- Topography (1)
- Impact of vadose zone (5)
- Hydraulic Conductivity of the aquifer (3)

(*In parantheses: weight*)

Total Score: Sum of all (score • weight)

S1 - Outcropping Gneiss

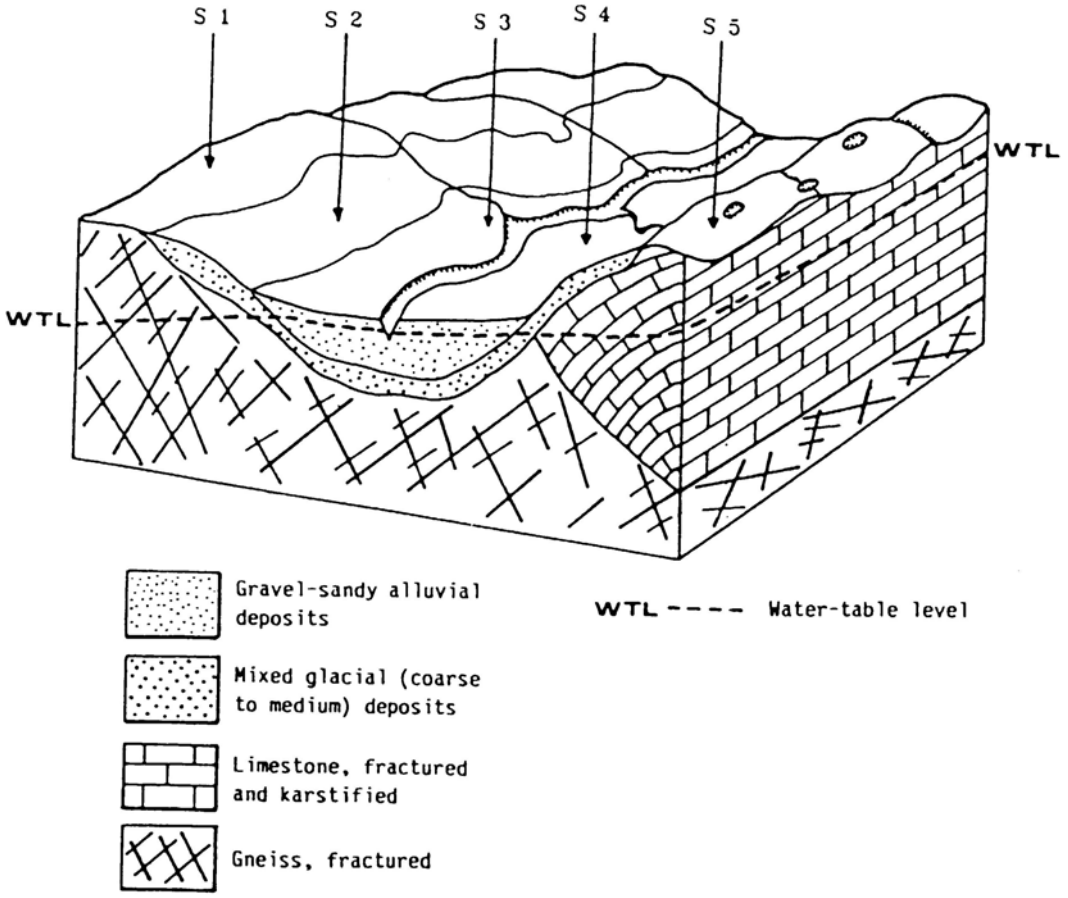
FACTOR	D A T A	RATING	* WEIGTH=	NUM.
D	>30 m	1	5	5
R	300 mm	9	4	36
A	Gneiss, fract.	5	3	15
S	Absent	10	2	20
T	>18%	1	1	1
I	Gneiss, fract.	4	5	20
C	E-05 m/s	9	3	27
		DRASTIC Index		124

S2 - Glacial deposits over Gneiss

FACTOR	D A T A	RATING	* WEIGHT=	NUM.
D	25 m	2	5	10
R	300 mm	9	4	36
A	Gneiss, fract.	5	3	15
S	Sandy	9	2	18
T	13%	3	1	3
I	Sand/grav/gneiss	5	5	25
C	E-05 m/s	9	3	27
		DRASTIC Index		134

S3 - Alluvial deposits

FACTOR	D A T A	RATING	* WEIGHT=	NUM.
D	3 m	10	5	50
R	300 mm	9	4	36
A	Gravel & Sand	8	3	24
S	Sandy loam	6	2	12
T	2%	10	1	10
I	Gravel & Sand	8	5	40
C	E-02 m/s	10	3	30
		DRASTIC Index		202



S4 - Glacial deposit over Limestone

FACTOR	D A T A	RATING	* WEIGHT=	NUM.
D	10 m	7	5	35
R	300 mm	9	4	36
A	Limestone, karst.	9	3	27
S	Sandy loam	6	2	12
T	18%	3	1	3
I	Sand/grav/Limes.	7	5	35
C	E-03 m/s	9	3	27
		DRASTIC Index		175

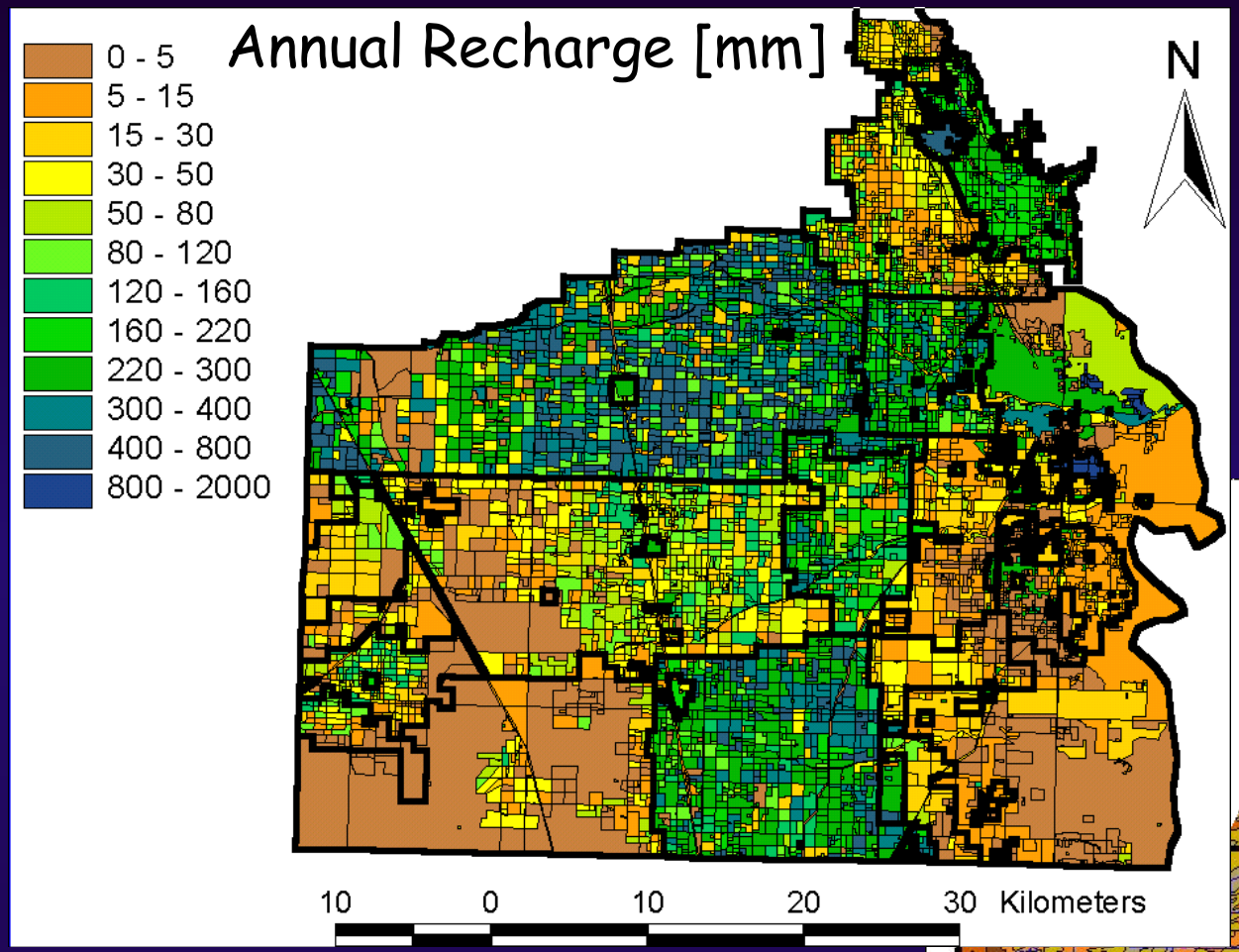
S5 - Outcropping Limestone

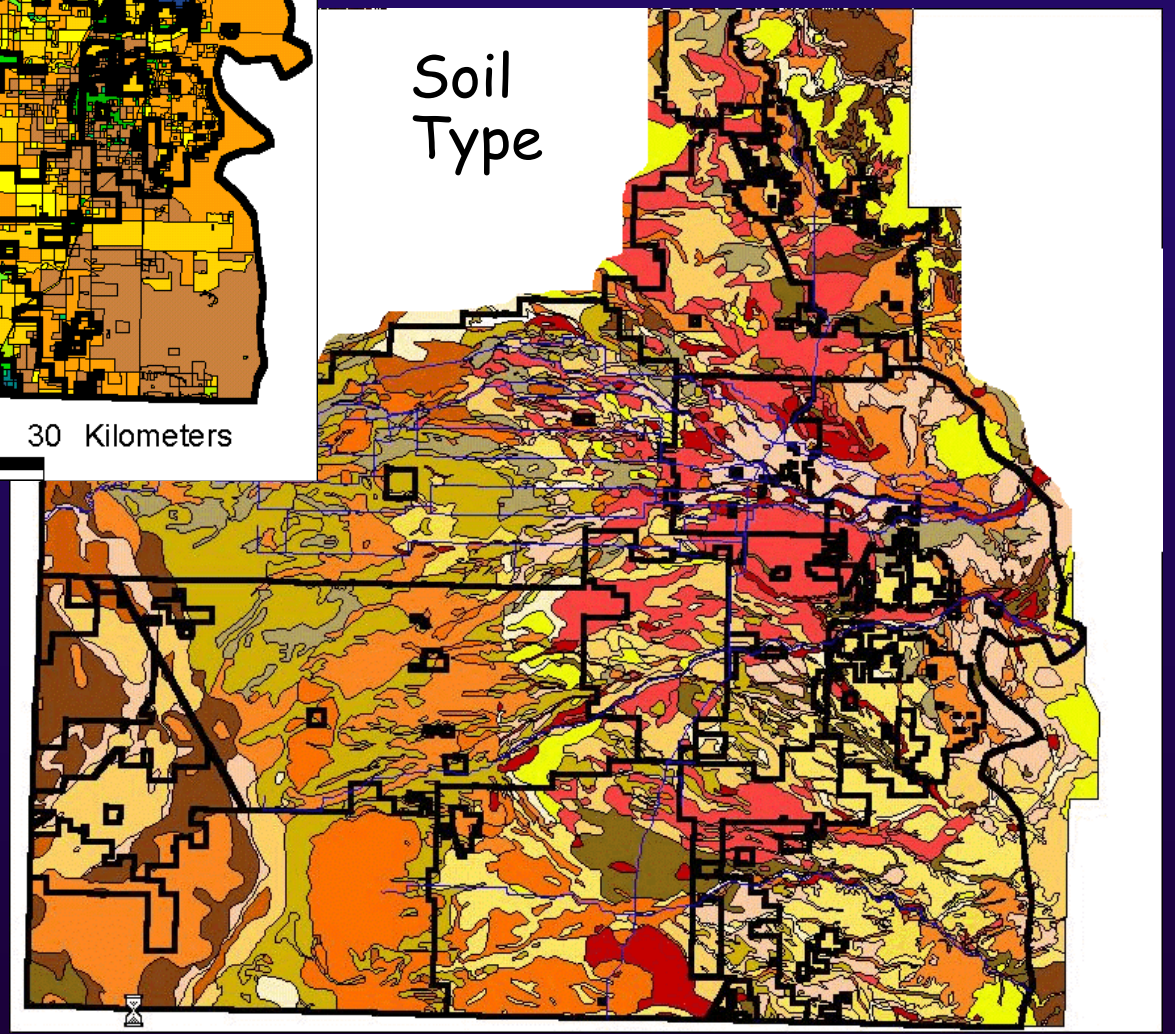
FACTOR	D A T A	RATING	* WEIGHT=	NUM.
D	>30	1	5	5
R	300 mm	9	4	36
A	Limestone, karst.	9	3	27
S	Absent	10	2	20
T	>18%	1	1	1
I	Limestone karst.	10	5	50
C	E-03 m/s	9	3	27
		DRASTIC Index		166

Figure 10. Examples of DRASTIC index in various hydrogeological settings (from Civita 1990a).

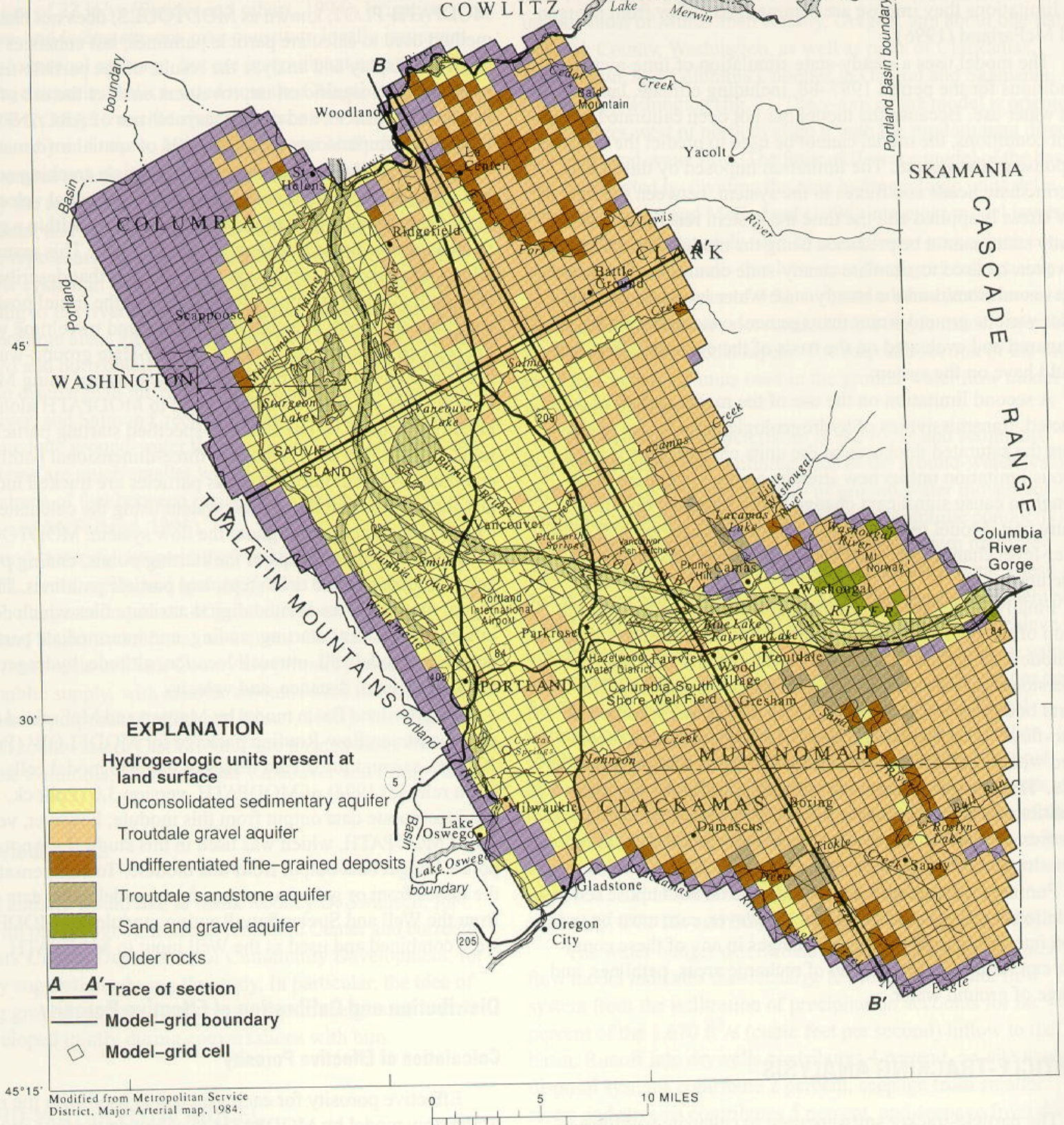
from:
Vrba and Zaporocec (eds.), 1994, Guidebook on Mapping Groundwater Vulnerability, International Association of Hydrogeologist, Volume 16

GIS Analysis





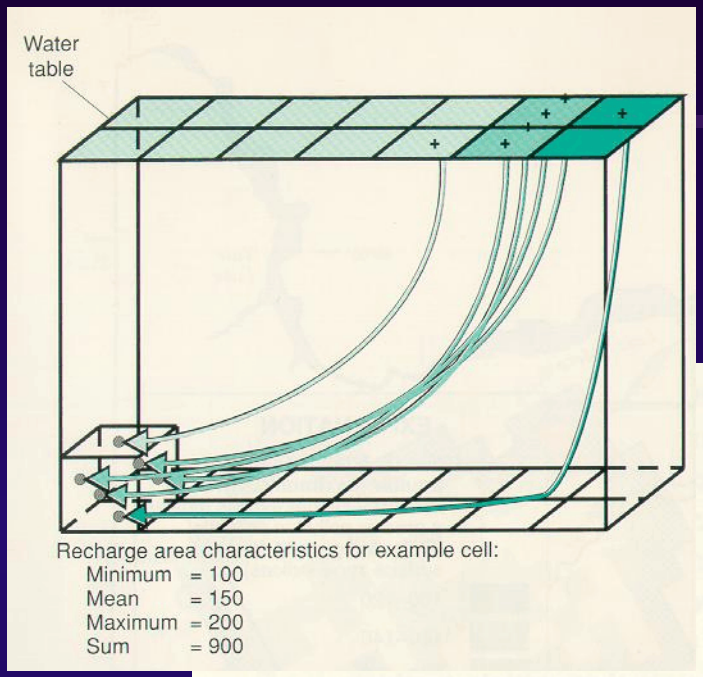
Process-based Models

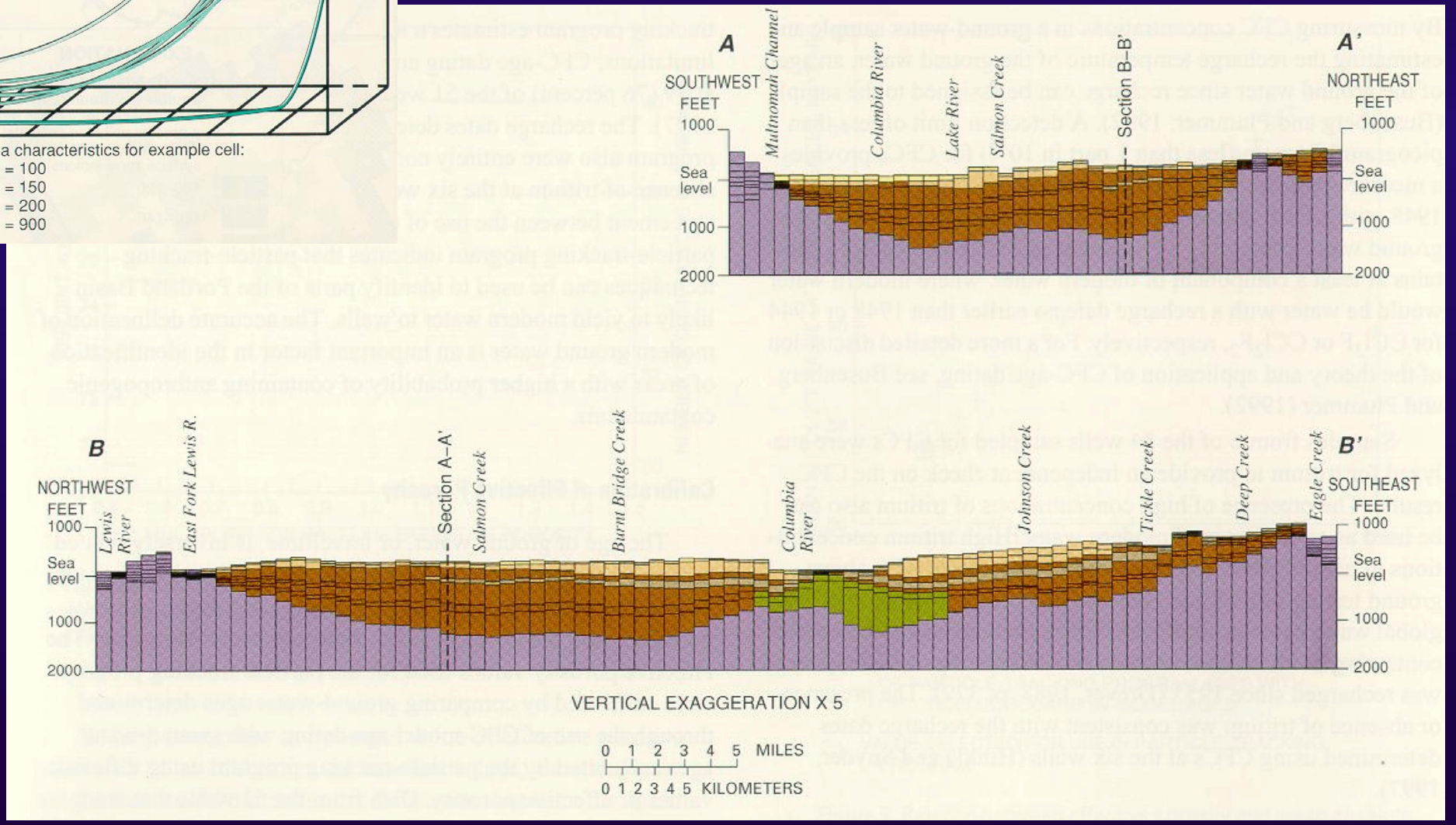


- Clark County, Washington (across from Portland, Oregon)

from:
USGS Water Supply Paper 2488, 1998

Process based Models





from:
USGS Water Supply Paper 2488, 1998